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RESEARCH PAPER

GRASSLANDS OF ASIA

Vascular plant diversity of the high mountains of Fereydunshahr, Central Zagros, Iran

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Abstract

Questions: The mountains of Fereydunshahr County are one of the centers of plant endemism within the Zagros, however, its flora and vegetation remain relatively understudied. In this study we undertook research on the plant species diversity of the subalpine and alpine zones of this area, their life forms, chorology, and vegetation types. **Study area:** Mountains of Fereydunshahr County, Central Zagros, West Iran. **Methods:** Plant specimens were collected during the growing seasons of 2018 to 2020. A complete species list was prepared including their life forms, chorotypes, elevation range, and major vegetation types. **Results:** A total of 308 vascular plant species have been identified belonging to 185 genera and 47 families. The largest plant families recorded during the study are *Asteraceae* with 44 species, *Fabaceae* 32, *Brassicaceae* 29, and *Lamiaceae* 27. At genus level *Astragalus* with 23 species is the richest. Hemicryptophyte with 162 (53%) species is the major life form. Most of the species are Irano-Turanian elements (52%). A total of 57 species (19%) are endemic to Iran and 23 species (7%) are endemic to Zagros. Most species belong to the montane-subalpine zone (33%), followed by subalpine (20%), montane (15%), lowland-montane (10%), alpine (9%), and lowland-subalpine (5%). In the alpine zone a high proportion of the species are endemic, while the montane zone has a very low proportion of endemics. From the identified species, 24% belong to subalpine and alpine thorn-cushion grasslands, 19% to montane steppe shrublands, 5% to subalpine tall-umbelliferous vegetation types, 5% to wetlands, and 5% to chasmophyte vegetation. **Conclusions:** The area has a rich flora, but at the same time is under high pressure from anthropogenic activities, especially a very high level of overgrazing. The region is not a protected area, therefore, establishment of a protected area and efficient conservation planning for the region is highly recommended.

Taxonomic reference: Flora of Iran (Assadi et al. 1989–2021) and, for families not yet covered in the previous source, Flora Iranica (Rechinger 1963–2015).

Abbreviations: ES = Euro-Siberian; IT = Irano-Turanian; M = Mediterranean; SS = Saharo-Sindian.

Keywords

alpine habitats, endemic species, mountains, plant diversity, Southwest Asia, vegetation types, Zagros

Introduction

Mountains are storehouses of global biodiversity and embrace half of the world's biodiversity hotspots (Mittermeier et al. 2011). Alpine ecosystems are found above the treeline, covering 3% of the Earth's land area and harbouring approximately 10,000 plant species (Nagy and Grabherr 2009; Körner 2021). These species are severely impacted by ongoing climate change (Dullinger et al. 2012; Pauli et al. 2012). Iran, with a total surface area of about 1.6 million km^2, is a high plateau in Southwest Asia, and almost half of the country is composed of high mountains, surrounding the interior lowlands. The alpine zone of the Iranian Mountains covers only about 1% of

the surface of the country but harbours 4% of non-endemic and 7% of the endemic flora of Iran (Noroozi et al. 2019b). In spite of the high endemic diversity of these habitats, there are many mountains that are not well explored yet and their subalpine and alpine plant diversity is not well known.

The Zagros is the largest mountain range in Iran, stretching from the northwest to the south of the country, with many peaks over 3,500 m a.s.l., harbouring wide scattered alpine ecosystems over a large area. The Zagros lies within the Irano-Turanian (IT) phytogeographic region (Zohary 1973; Manafzadeh et al. 2017) and has been identified as an area of endemism inside of the Irano-Anatolian global biodiversity hotspot (Mittermeier et al. 2011; Noroozi et al. 2019b, 2021). A global biodiversity hotspot is a region with a high number of endemic species and heavy impacts from human activities, resulting in a high priority for conservation (Mittermeier et al. 2011). The Zagros is home to a large number of endemic taxa, many of them limited to subalpine and alpine zones (Noroozi et al. 2020). Due to the large area and inaccessibility of certain areas, the Zagros is one of the less-known mountain ranges of the Iranian Plateau in terms of biodiversity. There are many centers of endemism in the Zagros, most of which are located in areas with high elevational amplitudes (Noroozi et al. 2019a). These areas were likely refugia, where many montane species of this mountain range survived during the last glacial periods (see Ahmadzadeh et al. 2013; Rajaei et al. 2013).

One of these centers of endemism is the mountains of Fereydunshahr County in Central Zagros, which covers only a small part of this mountain range (Figure 1). There have been several floristic and vegetation studies in the region and adjacent areas, including the flora and vegetation survey of Fereydunshahr (Nekookho 2008), the floristic study of Pashandegan forest reserve of Fereydunshahr (Hamidi Rad 2012), the study of the flora of Afus region (Shirvani Shahenayati et al. 2020) and the floristic study of Golestankooh area (Akhavan Roofigar and Bagheri 2021). However, the flora and vegetation at high elevations within this area have not been well documented. Therefore, the main goals of the current study are to conduct a floristic survey of the subalpine and alpine zones of the mountains of Fereydunshahr, their life forms, chorology, elevation zones and also the major vegetation types they are linked to. This study will contribute to the existing information on the plant diversity of the region and help to fill the gaps in the knowledge of biodiversity and conservation for the area.

Study area

The Fereydunshahr County (32° 56' N, 50° 07' E) is located about 180 km west of the city of Isfahan with an elevation of about 2,500 m a.s.l., surrounded by high mountains belonging to the Zagros range (Figure 1). The size of the study area is around 150 km^2, which covers less than 0.05% of the Zagros surface area. The most significant mountains of the study area are Mount Didtseri (3,620 m a.s.l.) in the north, Mount Zardigari (no-hunting area of the peak Setbleh) (3,700 m a.s.l.) in the northwest, Mount Kalabis kobi (3,000 m a.s.l.) in the northeast, Mount Tsikhe (3,320 m a.s.l.) in the west, and Mount Tatara (3,520 m a.s.l.) in the south. The region's geomorphology is shaped significantly by the Zagros Fault, which divides the area into the Elevated Zagros to the west and the Sanandaj-Sirjan zone to the east (Motaghi et al. 2017). The diverse limestone formations and soil composition, consisting mainly of Inceptisols and Entisols, reflect the area's rich geological history (Motaghi et al. 2017). The diverse landscape creates a variety of microclimates that support different vegetation types and ecological zones. The region is characterized by a Mediterranean climate regime with cold and wet winters and dry and warm summers (Djamali et al. 2011; Rivas-Martínez et al. 2011). The mean annual temperature is 11.65°C and the annual precipitation is 540 mm (Fereydunshahr meteorological station; Figure 2).

The main vegetation types of the region are defined based on previous studies which were reviewed in Noroozi et al. (2020). They are described briefly here for a better understanding of the study area:

Montane steppe shrublands is the main vegetation type in the montane zone, but reaching to the subalpine zone in some parts too. The species of the genera *Amygdalus*, *Cotoneaster* and *Cerasus* are the most characteristic shrubs in this vegetation type, and *Astragalus microcephalus* is usually the most common species. This vegetation type covers an elevation from ca. 1,200 to 2,700 m a.s.l.

Subalpine tall-umbelliferous vegetation types (Figure 3) are dominated by tall plants of the *Apiaceae* family such as *Ferula haussknechtii*, *Ferulago angulata* (Figure 3A), *Prangos ferulacea*, and *P. uloptera* (Figure 3B). These are typically found at elevations ranging from 2,500 to 3,500 m a.s.l., mostly on steep slopes with a high proportion of scree and stones, and poor soil content. This vegetation type was described as a provisional class named *Prangetea ulopterae* from Central Alborz (Klein 1988, 2001). Other dominant species are *Dorema aucheri*, *Ferula microcolea*, *Ferulago contracta*, *Pimpinella tragium*, *Rheum ribes*, *Rhabdosciadium aucheri*, and *R. straussii*.

Subalpine and alpine thorn-cushion grasslands are commonly found on the windswept slopes of subalpine and alpine zones (Figure 4). Three prominent species dominating these plant communities in the subalpine zone of Central Zagros (up to 3,500 m a.s.l.) are *Acantholimon hohenackeri*, *Astragalus brachycalyx*, and *Bromus tomentellus* (Figure 4A). Alongside these taxa, other frequently observed species include *Acantholimon aspadanum*, *A. senganense*, *Astragalus alyssoides*, *A. andalanicus*, *A. cephalanthus*, *A. rhodosemius*, and *A. susianus*. In the alpine zone (above ca. 3,500 m a.s.l.), *Astragalus murinus*, *A. raswendicus*, and *Cousinia multiloba* (Figure 4B) are the most dominant thorn-cushions. *Onobrychis cornuta* is another thorn-cushion species usually dominating in both subalpine and alpine windswept slopes (Figure 4C).

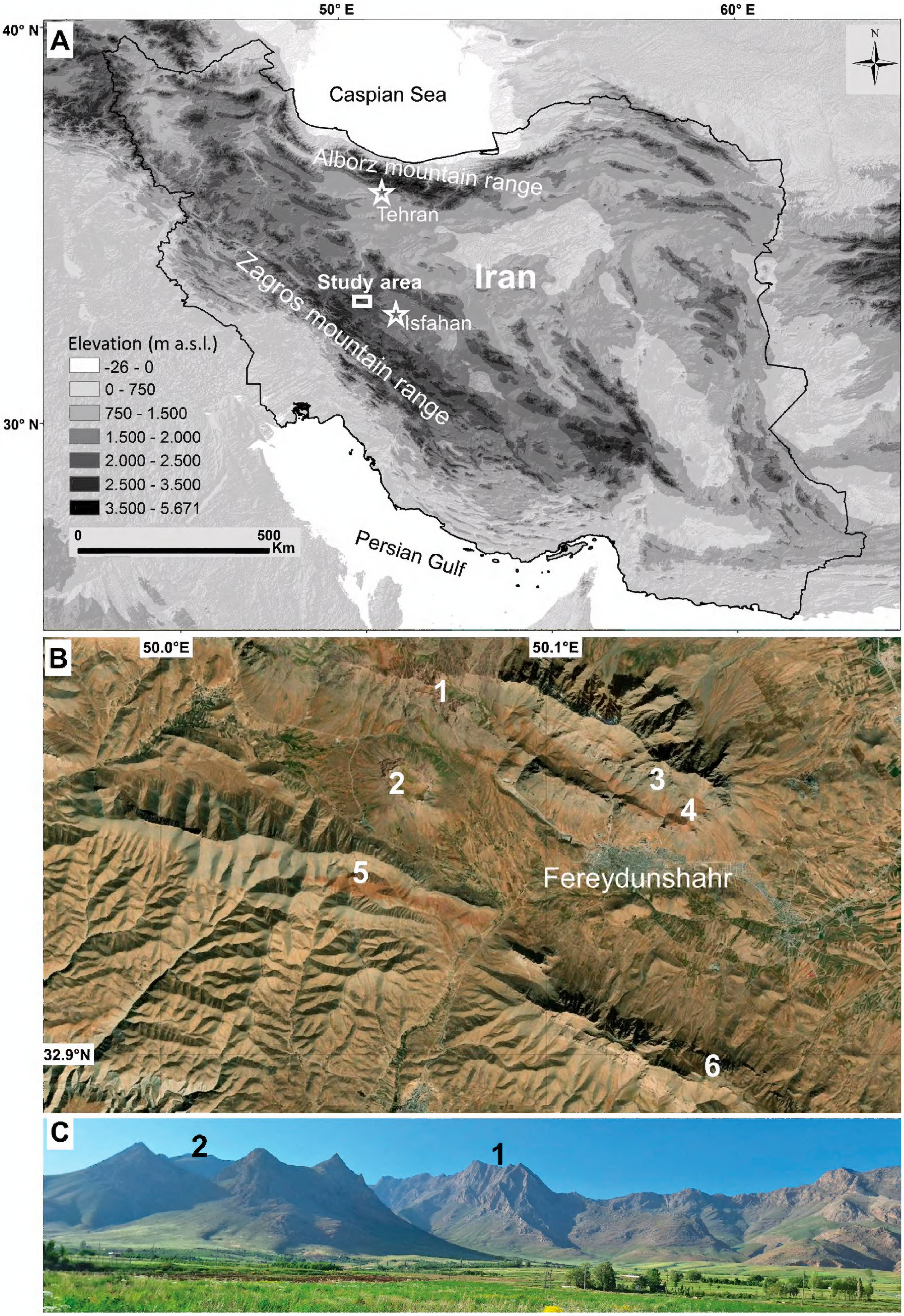

Figure 1. A. Topographic map of Iran and the location of the study area (made by Arc GIS). **B.** Satellite map of Fereydunshahr (map taken from Google Earth) showing the mountains within the study area. Mountain peaks are marked with white numbers: 1. Mount Zardigari (3,700 m a.s.l.) in the northwest, 2. Mount Tsikhe (3,320 m a.s.l.) in the west, 3. Mount Didtseri (3,620 m a.s.l.) in the north, 4. Mount Kalabis kobi (3,000 m a.s.l.) in the northeast, 5. Mount Ski Resort (3,091 m a.s.l.) in the west and 6. Mount Tatara (3,520 m a.s.l.) in the south. **C.** A view of the mountains around the city of Fereydounshahr. **A** was produced using ArcGIS; **B** is taken from Google Earth; **C** by MY.

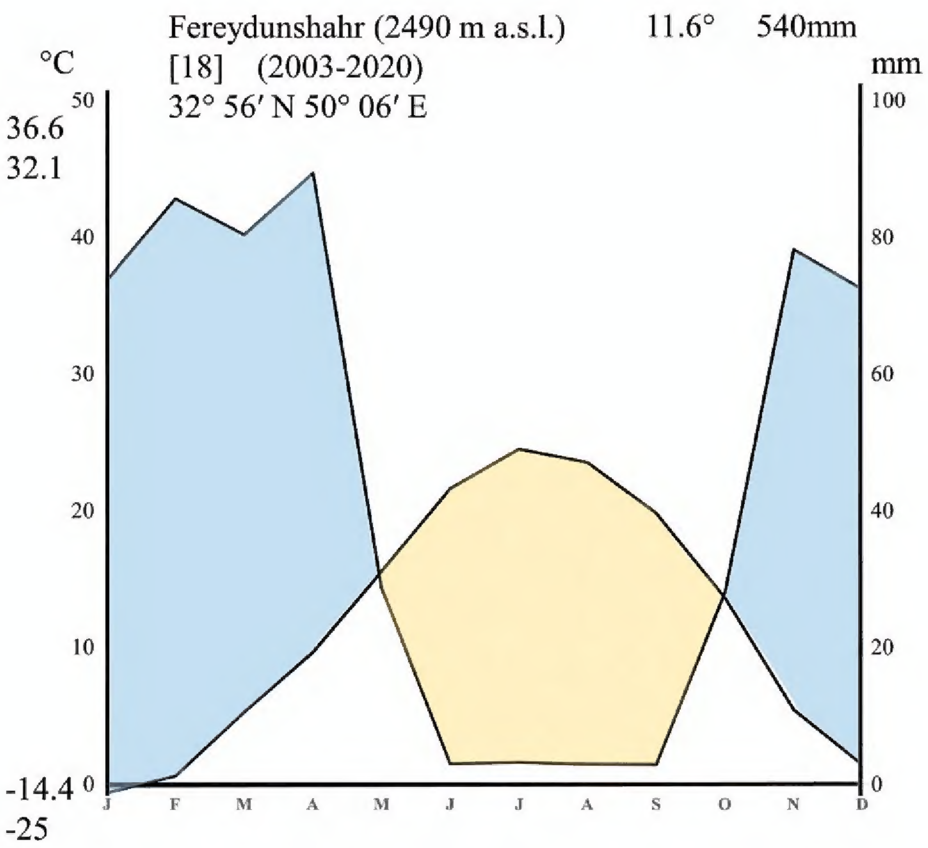

Figure 2. Climatic diagram of Fereydunshahr derived from the meteorological data collected by the Fereydunshahr meteorological station (https://www.irimo.ir/).

Chasmophytic vegetation (Figure 5) is distributed from the montane up to the nival zone. The substrate for this habitat is composed of volcanic rocks and limestone. Several characteristic species for this habitat in the subalpine and alpine zones are *Arabis caucasica* (Figure 5B), *Aubrieta parviflora*, *Corydalis rupestris*, *Dionysia bazoftica* (Figure 5C), *Graellsia saxifragifolia* (Figure 5D), *Pentanema pulicariiforme*, *Rosularia elymaitica*, and *Silene chlorifolia*.

Wetlands are found in areas with high moisture levels, such as near streams and wet meadows, at various elevations. They include species such as *Carex microglochin*, *Juncus articulatus*, *J. bufonius*, *J. inflexus*, *J. turkestanicus*, and *Mentha longifolia*.

Methods

Initially, several areas were delimited by closely examining the topographic map of Fereydunshahr County and its surrounding mountains. These areas were chosen to represent the diverse ecological and floristic characteristics

Figure 3. Subalpine tall-umbelliferous vegetation types. **A.** *Ferulago angulata* (Mount Zardigari, 3,450 m a.s.l.). **B.** *Prangos uloptera* (Mount Zardigari, 3,420 m a.s.l.). Photos by MY.

of the region. The multiple sites were selected to capture a wide range of environmental conditions, which can significantly influence plant species composition, such as different elevations, slopes, and aspects. This study was limited to an elevation range of between 2,500 to 3,700 m a.s.l.

The fieldwork was carried out during the growing season from April to September across three years (2018–2020) in the selected subalpine and alpine areas of Fereydunshahr. Sampling was done completely randomly from the slope to the top of the mountain, allowing us to cover a broad range of elevations and microhabitats. Over 1000 vascular plant specimens were collected, each tagged with detailed location, elevation, and habitat information. The collected specimens were identified using

Figure 4. Subalpine and alpine thorn-cushion grasslands. **A.** *Acantholimon hohenackeri*, *Astragalus brachycalyx*, *Bromus tomentellus*, *Dianthus macranthus* (Mount Ski Resort, 3,000 m a.s.l). **B.** *Cousinia multiloba* (Mount Tatara, 3,500 m a.s.l). **C.** *Onobrychis cornuta* (Mount Zardigari, 3,535 m a.s.l. Photos by MY.

Figure 5. A. View of the rock habitat with chasmophytic vegetation (Mount Zardigari, 3,700 m a.s.l.). Examples of chasmophytic species: **B.** *Arabis caucasica* (Mount Zardigari, 3,400 m a.s.l). **C.** *Dionysia bazoftica* (Mount Tatara, 3,050 m a.s.l). **D.** *Graellsia saxifragifolia* (Mount Zardigari, 3,400 m a.s.l. Photos by MY.

relevant floras including Flora Iranica (Rechinger 1963–2015) and Flora of Iran (Assadi et al. 1989–2021). All specimens were deposited in the Herbarium of the University of Isfahan (HUI) for future reference and study. We assigned the species to the major vegetation types (to one or to a combination of types), the elevation zones, and chorotypes, based on our field observations during this study, our observations in other mountain ranges, literature studies, and using Flora Iranica (Rechinger 1963–2015), and Flora of Iran (Assadi et al. 1989–2021). Raunkiaer's classification system (Raunkiaer 1934) was used to determine the life forms of plants, classified into five groups: chamaephytes, geophytes, hemicryptophytes, phanerophytes, and therophytes.

Results and discussion

Flora

A total of 308 vascular plant species belonging to 185 genera and 47 families were identified in this study (Appendix 1). From those, 306 species are angiosperms, while there is only one pteridophyte (*Equisetum arvense*) and one gymnosperm (*Juniperus excelsa*) species. Eudicots accounted for 261 species (85%), while Monocots accounted for 45 species (15%). The largest plant families identified in the area were *Asteraceae* with 44 species, *Fabaceae* with 32 species, *Brassicaceae* with 29 species, *Lamiaceae* with 27 species, *Apiaceae* with 20 species, and *Poaceae* with 18 species (Figure 6A). The order of big families in this region is similar to the entire flora of the Zagros mountain range (Noroozi et al. 2020). Furthermore, the highest number of species among the genera was found in the genus *Astragalus* (23 species), followed by *Allium* (7 species), *Scorzonera* (6 species), *Nepeta* and *Stachys* (both with 5 species; Figure 6B). *Astragalus*, the biggest genus in Iran in terms of number of species (ca. 885 species) and also number of endemics (ca. 589 species; Maassoumi and Khajoei Nasab 2023), is the richest genus in the study area too with high number of endemics to Iran (14 species) and Zagros (6 species). *Allium*, the third biggest genus of Iran with ca. 140 species and ca. 60% endemics (Noroozi et al. 2019b), is the second richest genus in the study area with seven species and only one endemic to Iran. Interestingly, *Cousinia*, which is the second biggest genus of Iran with ca. 300 species and ca. 80% endemics, only has four species in the study area, two of them endemic to Iran. The low species richness of this genus in the study area is probably linked to the fact that *Cousinia* is represented by a low number of species in the alpine zone of Iran (Noroozi et al. 2008).

Life forms

Species adaptations towards climatic variables are reflected in a plant's life forms (Raunkiaer 1934; Cornelissen et al. 2003). Our results show that hemicryptophytes are the most common life form in the study area with 53%, followed by therophytes, geophytes, chamaephytes, and phanerophytes (Figure 7A). Hemicryptophytes are a dominant life form in alpine habitats worldwide (Körner 2021), and the most common one with 76% in the alpine flora of Iran (Noroozi et al. 2008). They are successful in alpine habitats due to having buds located at or just below ground, which protects from frost and desiccation, and also their low-growing structures reduce exposure to wind and retain heat (Körner 2021). Of the 49 therophyte species identified, only three are specifically subalpine and alpine and the rest belong to lower elevation zones reaching the subalpine zone. The strategy of therophytes creates an adaptation to the water limit of the Mediterranean climate, and they are the most dominant life form in Mediterranean open lands, in terms of number of species (e.g. Pignatti 2003; Lazarina et al. 2019). However, this life form has a low proportion in alpine habitats compared to lower elevations, due to the short growing season in alpine habitats (Körner 2021). In the alpine flora of Iran, this life form is only 2.5% of the total, which is very low compared to the flora of lower elevations of the region (Noroozi et al. 2008). The proportion of geophytes significantly increases along the elevation gradient in the Mediterranean regions (Lazarina et al. 2019), but in our study, geophytes are more common in the montane zone and less present in alpine habitats. Only 7% of the subalpine and alpine species of this study are geophytes. This result is in line with the proportions of geophytes in the alpine flora of Iran (6%; Noroozi et al. 2008). Phanerophytes, mainly shrubs, are distributed predominantly in the montane zone (montane steppe shrublands) but also extend into the lower elevations of the subalpine zone. Species of *Amygdalus*, *Cerasus*, *Cotoneaster*, *Rosa*, and *Daphne* are among them. *Juniperus excelsa* is another species which in some areas of Alborz and Zagros is dominant in the treeline zone creating *Juniperus* woodlands, but it has become very scarce in most parts of these mountains, including the study area, more likely due to anthropogenic activities (Akhani et al. 2013; Ravanbakhsh et al. 2016).

Chorotypes

In terms of chorotypes, the majority of the identified species belong to the IT region (52%). Other significant chorotypes include combinations of the IT, Euro-Siberian (ES), and Mediterranean (M) regions (Figure 7B). Interestingly, the floristic affinity with the ES region is stronger than with the M region (Figure 7B), while for the entire Zagros flora, the floristic affinity with the M region is stronger (Noroozi et al. 2020). This can be due to the elevation zone of the study area, as with increasing elevation, the floristic affinity to the ES region increases and to the M and Saharo-Sindian (SS) regions decreases. This may be due to climatic factors such as higher precipitation and lower temperatures at higher elevations. In addition, the Alborz and Zagros have always acted as migration corridors between Central Asia and the European mountains (Manafzadeh et al. 2014) which can be another reason for the high floristic similarity between these mountains and the ES high mountains. The floristic affinity with the SS region is very poor in the study area (Figure 7B), which could be expected due to the very dry climate (Djamali et al. 2011) and poor mountain ecosystems of the SS region.

Approximately 19% of the identified species are endemic to Iran, and 7% are endemic to the Zagros mountain range. Comparative studies, such as those by Noroozi et al. (2019a, 2019b), have documented endemic species distribution across Iran, showing different rates of endemism in different parts, including the Zagros mountain range. Based on Noroozi et al. (2019a), mountains of Fereydunshahr are centers of endemism and among the top 10% richest endemic hotspots in the Iranian Plateau.

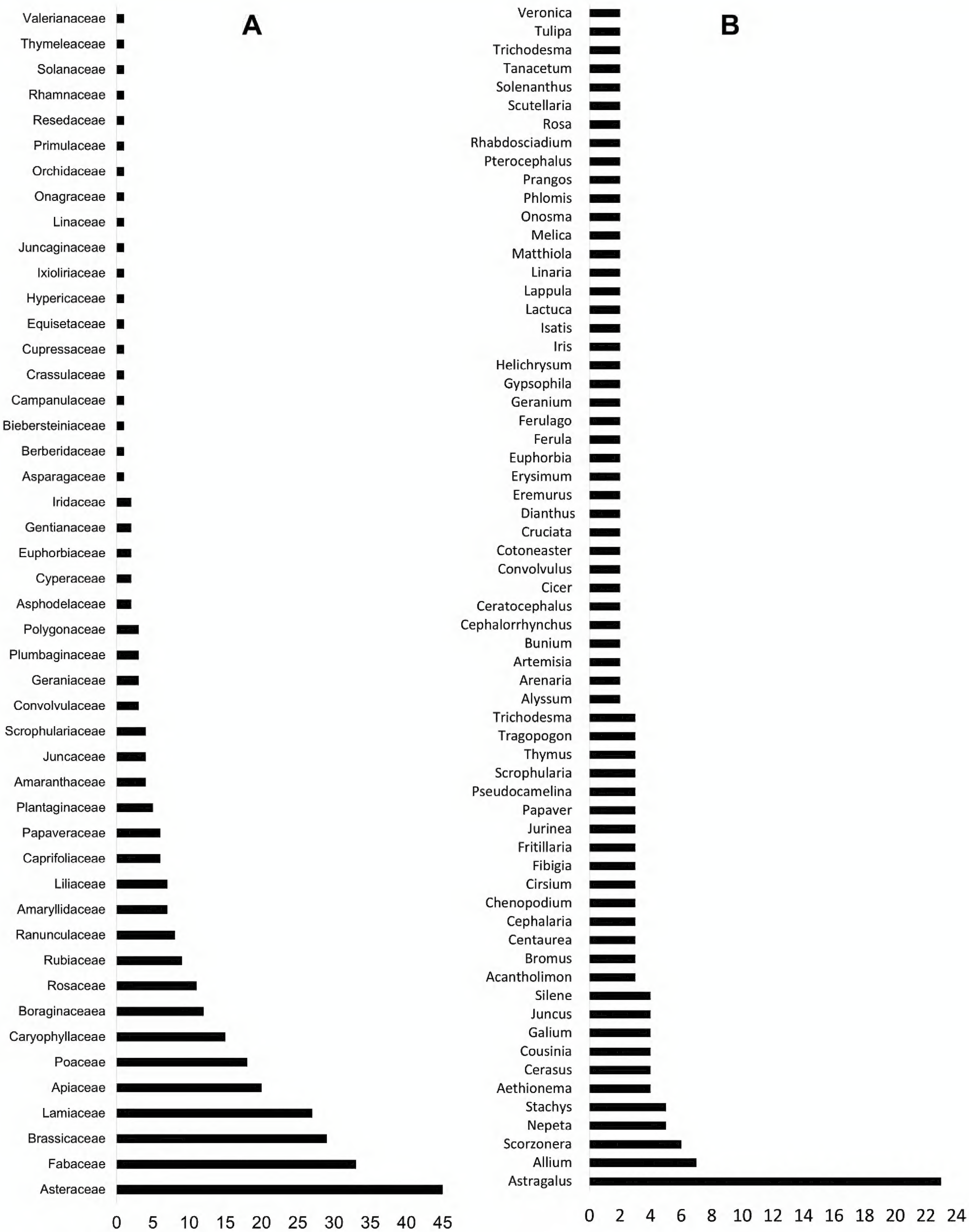

Figure 6. The number of plant species in each family **(A)** and each genus **(B)** within the study area. Only genera having more than two species are shown.

Species within elevation zone

A considerable number of species are distributed in both montane and subalpine zones (33%; Table 1), 20% of the species are subalpine and only 9% are alpine species, while 8% of species are distributed across both the subalpine and alpine zones. Montane species (15%) are particularly prevalent in the study area. Many species recorded in this study have their optimal elevation distribution in the montane zone, but their upper elevation

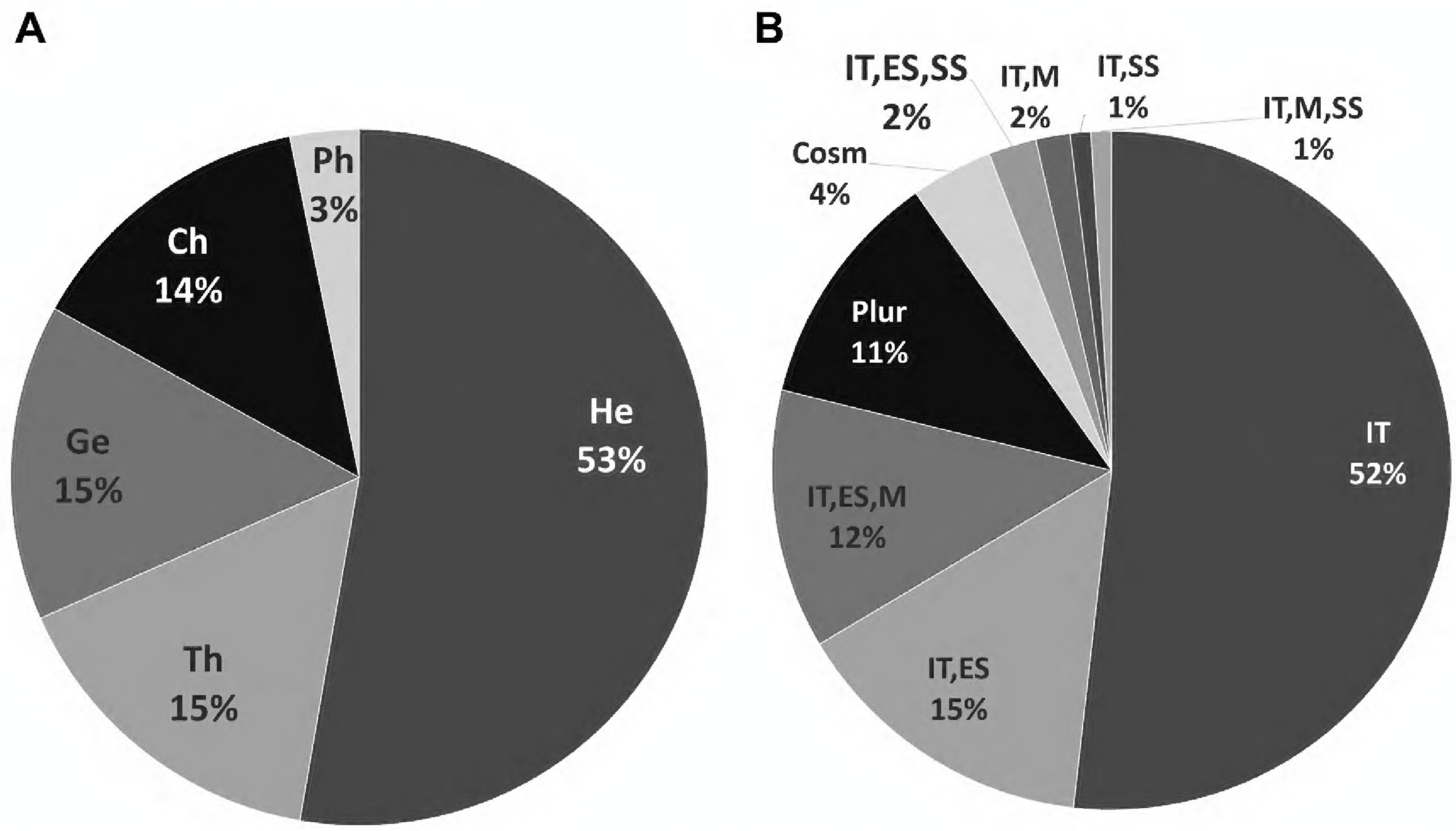

Figure 7. A) The percentage of life forms in the study area (Ch: chamaephytes, Ge: geophytes, He: hemicryptophytes, Ph: phanerophytes, and Th: therophytes). **B)** Chorotypes of species in the region (IT: Iranian-Turanian, ES: Euro-Siberian, M: Mediterranean, SS: Saharo-Sindian, Cosm: Cosmopolitan, Plur: Pluriregional).

range extends to the subalpine zone (above 2,500 m a.s.l) and thus are frequent within the study area. The highest summit within the study area is 3,700 m a.s.l. and only a small area of true alpine habitat exists within the study area. Therefore, the size of the alpine zone in this region is small, and only ca. 9% of the species are real alpine species. The decreasing species richness along elevation gradients that is observed during this study, follows the general trend observed in mountains worldwide, driven by reductions in both surface area and temperature (Peters et al. 2016; Körner 2021).

Although the number of alpine species is low, most of them are endemics to Iran (57%). In the lower elevation zones, the rate of endemics is lower, with 38% and 20% for subalpine and montane zones, respectively (Table 1). This is in line with previous studies that show that the rate of endemism increases along elevation gradients in different parts of the world (Irl et al. 2015; Steinbauer et al. 2016), and our specific region (Noroozi et al. 2019b, 2024). High endemism at higher elevations is caused by increasing isolation which increases allopatric speciation rates (Hughes and Atchison 2015; Steinbauer et al. 2016).

Species within major vegetation types

As presented in Table 2, most of the species belong to the subalpine and alpine thorn-cushion grasslands (24%), which cover a major part of the study area and have the biggest gamma diversity. Moreover, this vegetation type has an optimal length of growing season at this elevation due to its short snow cover duration. The length of snow cover determines the length of growing season in alpine habitats, one of the most important factors determining the species composition in general (Körner 2021), and in the high mountains of Iran in particular (Noroozi et al. 2010; Noroozi and Körner 2018). Additionally, the tightly packed apical meristems of cushions, along with a dense layer of stems and dead leaves, can effectively buffer against environmental extremes (Cavieres et al. 2007). This makes cushion plants important foundation species that facilitate and support many other species that struggle to survive or cannot exist at all in the surrounding open areas, they function as micro-refugia by facilitating less stress-tolerant species in severe environments (Cavieres and Badano 2009; Butterfield et al. 2013). This facilitation has an im-

Table 1. Occurrence of plant species in different elevation zones of Fereydunshahr. The number of species in each zone, their proportion of the entire flora, number of endemics to Iran in each zone and proportion of the endemics in each zone are presented.

Category	Elevation range (m a.s.l.)	No. species	% species	No. endemics	% endemics
Montane-Subalpine (ms)	1200–3400	102	33	26	25
Subalpine (s)	2700–3400	62	20	23	37
Montane (m)	1200–2700	46	15	9	20
Lowland-Montane (lm)	<1200–2700	30	10	0	0
Alpine (a)	3400–4000	28	9	16	57
Subalpine-Alpine (sa)	2700–4000	24	8	5	22
Lowland-Subalpine (ls)	<1200–3400	16	5	0	0

Table 2. Number and percentage of species and endemic species in different vegetation types of Fereydunshahr.

Vegetation types	No. Species	% Species	No. Endemics	% Endemics
Subalpine and alpine thorn-cushion grasslands	75	24	28	38
Montane steppe shrublands & Subalpine and alpine thorn-cushion grasslands	69	23	21	30
Montane steppe shrublands	57	19	8	14
Montane steppe shrublands & Subalpine tall-umbelliferous vegetation types & Subalpine and alpine thorn-cushion grasslands	24	8	2	8
Ruderal	28	9	1	4
Subalpine tall-umbelliferous vegetation types	16	5	9	56
Wetlands	14	5	1	7
Chasmophytes	14	5	6	43
Subalpine tall-umbelliferous vegetation types & Subalpine and alpine thorn-cushion grasslands	11	4	3	27

portant role in increasing the alpha, gamma and phylogenetic diversity of the communities with a dominant cushion life form (Butterfield et al. 2013; Cavieres et al. 2014).

Moreover, 19% of species belong to montane steppe shrublands, 5% to subalpine tall-umbelliferous vegetation types, 5% to wetlands, and 5% to chasmophytic vegetation. A high proportion of species are distributed in both montane steppe shrublands and subalpine and alpine thorn-cushion grasslands (23%). The rest of the species belong to multiple vegetation types which are uncommon within the study area. The rate of endemicity in different vegetation types is very variable. A high proportion of species in the subalpine tall-umbelliferous vegetation types are endemic to Iran (56%), followed by chasmophytic vegetation (43%), subalpine and alpine thorn-cushion grasslands (38%), montane steppe shrublands (14%), wetlands (7%) and ruderals (4%). In general, across diverse regions, the proportion of endemics is high in scree and chasmophytic habitats (Hobohm 2014) and low in wetlands and ruderal habitats which usually are widely distributed (Naqinezhad et al. 2010; Hobohm 2014). We do not have an entire species list for the subalpine tall-umbelliferous vegetation types of Zagros, or entire high mountains of Iran, or Southwest Asia, to be able to compare with other vegetation types to confirm if high endemicity is a general character for this vegetation type or just a local character. However, we know that scree habitats in high mountains have rich endemic diversity (Hobohm 2014) and subalpine tall-umbelliferous vegetation types are typical of steep slopes with screes in Southwest Asian Mountains (Noroozi 2020).

Conclusion

In general, this study provides valuable insights into the flora of the subalpine and alpine zones of Fereydunshahr County with their life forms, chorotypes, elevation zones, and vegetation types occurring in the area. This study also highlights the species richness of certain areas. However, there were several limitations to the study that need to be considered. Despite extensive fieldwork and efforts to identify all species, the species list presented in this study may not be comprehensive, due to seasonal variations, inaccessibility of certain areas, and the problem of overlooking small species. Further research, including detailed vegetation data collection and analysis is required, to fully understand these ecosystems, the dynamics within plant communities, and the effects of environmental variables on species composition and vegetation dynamics, to ensure an accurate representation of the region's flora. Such in-depth investigations are essential for developing effective conservation strategies and ensuring the sustainable management of these valuable ecological areas.

Although the region is identified as a center of endemism, there is no protected area to conserve the natural habitats of the region (Noroozi et al. 2019a). The area faces several significant threats that put the rich biodiversity and endemic species of the area at risk. Habitat destruction driven by anthropogenic activities such as overgrazing, agricultural expansion, and infrastructure projects such as roads, dams and mines, fragment and reduce natural habitats. Based on paleobotanical studies, the vegetation types of Zagros have been clearly impacted by anthropogenic activities over the last five millennia (Djamali et al. 2009). According to genetic studies, goats were domesticated in the Zagros (Zeder and Hesse 2000) and the history of goat herding in the Central Zagros goes back to ca. 10,000 years ago (Gallego-Llorente et al. 2016). Currently, overgrazing by livestock is very significant in these mountains and leads to soil erosion and degradation of the plant communities (Hashemi et al. 2019; Bagheri et al. 2022). The abundance of poisonous and/or thorny species, such as *Euphorbia*, *Cirsium*, and *Cousinia* (overgrazing indicators) in the highlands of Fereydunshahr indicates that there is a high pressure from overgrazing. Illegal harvesting and the collection of rare plants for trade also threaten the existence of many species. Climate change and global warming, altering precipitation patterns and temperature regimes, which can shift vegetation zones and disturb the ecological balance of the high mountain biodiversity, are a threat to all alpine habitats (Dullinger et al. 2012; Pauli et al. 2012). Addressing these threats is fundamental for comprehensive protection and conservation strategies, including habitat preservation, strict regulation of land use, and community engagement in conservation efforts to preserve the unique ecological value and biodiversity of the mountains of Fereydunshahr.

Data availability

All data are presented in the paper.

Author contributions

AB and JN got the idea and planned the research. MY conducted the field sampling, identified the species, analyzed the data, and drafted the manuscript. AB and JN contributed to species identification, and manuscript writing and editing. All authors read and agreed to the published version of the manuscript.

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Appendix 1

Table A1. Complete list of vascular plants in the subalpine and alpine zones of the mountains in Fereydunshahr along with their characteristics. Abbreviations: **Life form:** Ch = chamaephyte, He = hemicryptophyte, Ph = phanerophyte, Th = therophyte, Ge = geophyte; **Chorotypes:** Cosm = Cosmopolitan, ES = Euro-Siberian, IT = Irano-Turanian, M = Mediterranean, Plur = Pluriregional, SS = Sahara-Sindian; **Endemic:** Ir = endemic to Iran, Za = endemic to Zagros; **Elevation zones:** a = alpine, s = subalpine, m = montane, lm = lowland-montane, ls = lowland-subalpine, ms = montane-subalpine, sa = subalpine-alpine; **Vegetation types:** 1 = Ruderal, 2 = Wetlands, 3 = Chasmophytic vegetation, 4 = Montane steppe shrublands, 5 = Subalpine tall-umbelliferous vegetation, 6 = Subalpine and alpine thorn-cushion grasslands.

Species	Endemic	Vegetation types	Elevation zones	Life form	Chorotype
Amaranthaceae					
Chenopodium album L.	-	1	ls	Th	Cosm
Chenopodium botrys L.	-	1	ms	Th	Plur
Chenopodium foliosum Asch.	-	1	sa	Th	Plur
Noaea mucronata (Forssk.) Asch. & Schweinf.	-	1	m	Ch	IT, M, SS
Amaryllidaceae					
Allium ampeloprasum L.	-	4	lm	Ge	IT, M, SS
Allium austroiranicum R.M.Fritsch	Ir	5	s	Ge	IT
Allium fibrosum Regel	-	4, 6	ms	Ge	IT
Allium stipitatum Regel	-	6	sa	Ge	IT, ES
Allium pseudoampeloprasum Miscz. ex Grossh.	-	4	m	Ge	IT, ES
Allium scabriscapum Boiss.	-	4	m	Ge	IT
Allium xiphopetalum Aitch. & Baker	-	4, 6	ms	Ge	IT
Apiaceae					
Apium nodiflorum (L.) Lag.	-	5	ms	Ge	Plur
Astrodaucus orientalis (L.) Drude	-	1	m	Th	IT
Bunium caroides (Boiss.) Hausskn. ex Bornm.	-	1	ms	Ge	IT
Bunium luristanicum Rech.f.	Ir	1	m	Ge	IT
Dorema aucheri Boiss.	Ir	5	s	He	IT
Elaeosticta nodosa (Boiss.) Boiss.	Za	4	m	Ge	IT
Eryngium billardieri Delile	-	5	ms	He	IT, ES
Ferula haussknechtii H.Wolff ex Rech.f.	-	5	s	He	IT
Ferula microcolea (Boiss.) Boiss.	Ir	5	s	He	IT
Ferulago angulata (Schltdl.) Boiss.	-	5	s	He	IT
Ferulago contracta Boiss. & Hausskn.	Ir	5	s	He	IT
Pimpinella tragium Vill.	-	5, 6	sa	He	IT, M, ES
Prangos ferulacea (L.) Lindl.	-	5	s	He	IT, M
Prangos uloptera DC.	-	5	s	He	IT
Rhabdosciadium aucheri Boiss.	Za	5	s	He	IT
Rhabdosciadium straussii Hausskn. ex Bornm.	Ir	5	s	He	IT
Scandix iberica M.Bieb.	-	1	ls	Th	IT, ES
Thecocarpus meifolius Boiss.	Ir	5	ms	He	IT
Turgenia latifolia (L.) Hoffm.	-	1	ls	Th	IT, M, ES
Zeravschania aucheri (Boiss.) Pimenov	Ir	5	ms	He	IT
Asparagaceae					
Muscari neglectum Guss. ex Ten.	-	4	ms	Ge	IT, M, ES
Asphodelaceae					
Eremurus persicus (Jaub. & Spach) Boiss.	-	6	sa	Ge	IT
Eremurus spectabilis M.Bieb.	-	6	s	Ge	IT, ES
Asteraceae					
Achillea wilhelmsii K.Koch	-	1	lm	He	IT, M, ES
Arctium lappa L.	-	1	m	He	Plur
Artemisia haussknechtii Boiss.	-	3	sa	He	IT
Artemisia persica Boiss.	-	6	a	Ch	IT, ES
Centaurea aucheri (DC.) Wagenitz	-	4, 6	ms	He	IT
Centaurea depressa M.Bieb.	-	1	m	Th	IT, ES
Centaurea virgata Lam.	-	1	m	He	IT, ES
Cephalorrhynchus microcephalus (DC.) Schchian	-	1	lm	Ge	IT
Cephalorrhynchus rechingerianus Tuisl	-	1	Ls	Ge	IT
Cichorium intybus L.	-	1	Ls	He	Plur
Cirsium bracteosum DC.	-	4, 6	ms	He	IT
Cirsium congestum Fisch. & C.A.Mey. ex DC.	-	4	m	He	IT, ES
Cousinia bachtiarica Boiss. & Hausskn.	Za	6	s	He	IT

Species	Endemic	Vegetation types	Elevation zones	Life form	Chorotype
Cousinia cylindracea Boiss.	Ir	6	s	He	IT
Cousinia lasiolepis Boiss.	-	6	a	He	IT
Cousinia multiloba DC.	-	6	a	He	IT
Crepis micrantha Czerep.	-	4	lm	Th	Plur
Echinops ritrodes Bunge	-	4, 6	ms	He	IT
Gundelia tournefortii L.	-	4	m	He	IT, M, ES
Helichrysum globiferum Boiss.	Ir	4, 6	ms	Ch	IT
Helichrysum oligocephalum DC.	Ir	6	s	Ch	IT
Iranecio paucilobus (DC.) B.Nord.	-	6	s	He	IT
Inula britannica L.	-	4, 6	ms	He	IT, M, ES
Jurinea eriobasis DC.	Ir	4	m	He	IT
Jurinea meda Bornm.	Za	6	a	He	IT
Jurinea prasinophylla Rech.f.	Za	4	m	He	IT
Lactuca orientalis (Boiss.) Boiss.	-	4, 6	ms	He	Plur
Lactuca serriola L.	-	4	m	He	Plur
Pentanema pulicariiforme (DC.) Rech.f.	Ir	3	s	He	IT
Phagnalon persicum Boiss.	Ir	3	a	He	IT
Psychrogeton alexeenkoi Krasch.	-	3	a	He	IT, ES, SS
Scorzonera calyculata Boiss.	Ir	6	a	He	IT
Scorzonera ispahanica Boiss.	Ir	4	m	He	IT
Scorzonera laciniata L.	-	4	lm	Th	IT, M, ES
Scorzonera pseudolanata Grossh.	-	4	m	He	IT, Es
Scorzonera ramosissima DC.	-	6	s	Ch	IT
Scorzonera mucida Rech.f., Aellen & Esfand	-	4	m	Ge	IT
Senecio vernalis Waldst. & Kit	-	4, 6	ms	Th	IT, M, ES
Tanacetum polycephalum Sch.Bip.	-	6	a	He	IT
Tanacetum uniflorum (Fisch. & C.A.Mey. ex DC.) Sch.Bip.	-	4, 6	ms	Ch	IT, ES
Tragopogon bakhtiaricus Rech.f.	Za	6	a	He	IT
Tragopogon jesdianus Boiss. & Buhse.	Ir	4, 6	ms	He	IT
Tragopogon longirostris Sch.Bip	-	4, 6	ms	He	IT, M, ES
Xeranthemum longepapposum Fisch. & C.A.Mey.	-	4, 6	ms	Th	IT, ES
Berberidaceae					
Leontice leontopetalum L.	-	4	m	He	IT, ES, SS
Biebersteiniaceae					
Biebersteinia multifida DC.	-	6	s	Ge	IT, ES
Boraginaceae					
Anchusa italica Retz.	-	1	m	He	IT, M, ES
Lappula barbata (M.Bieb.) Gürke	-	4, 6	ms	Th	IT, M, ES
Lappula microcarpa (Ledeb.) Gürke	-	6	s	Th	IT, M, ES
Nonea persica Boiss.	Ir	4, 6	ms	He	IT
Onosma demavendica Riedl.	Ir	4, 6	ms	Ge	IT
Onosma kotschyi Boiss.	Ir	4, 6	ms	He	IT
Rindera lanata Bunge	-	4, 6	ms	He	IT, ES
Solenanthus circinnatus Ledeb.	-	6	s	He	IT, ES
Solenanthus stamineus J.F.Macbr.	-	6	a	He	IT, M, ES
Trachelanthus cerinthoides Kunze	-	4, 6	ms	He	IT
Trichodesma aucheri DC.	Ir	4, 6	ms	He	IT
Trichodesma incanum (Bunge) A. DC.	-	4, 6	ls	He	IT, ES
Brassicaceae					
Aethionema arabicum (L.) Andrz. ex DC.	-	4	lm	Th	IT, ES
Aethionema elongatum Boiss.	-	4, 6	ms	He	IT
Aethionema stenopterum Boiss.	Ir	3	ms	He	IT
Aethionema trinervium (DC.) Boiss.	-	6	sa	He	IT
Alyssum bracteatum Boiss. & Bushe	Ir	4, 6	ms	He	IT
Alyssum heterotrichum Boiss.	-	4, 6	ms	He	IT
Arabis caucasica Willd.	-	3	sa	He	IT, M, ES
Aubrieta parviflora Boiss.	-	3	ms	He	IT
Brossardia papyracea Boiss.	-	4	m	He	IT
Cardaria draba (L.) Desv.	-	1	m	Th	Cosm
Clypeola lappacea Boiss.	-	4, 6	ms	Th	IT
Conringia persica Boiss.	-	4, 6	ms	Th	IT
Descurainia sophia (L.) Webb ex Prantl	-	1	ms	Th	IT, M, ES
Drabopsis verna K.Koch	-	4, 6	ms	Th	IT, M, SS
Erysimum badghisi (Korsh.) Lipsky ex N.Busch	-	6	s	He	IT
Erysimum griffithianum Boiss.	-	4, 6	ms	He	IT

Species	Endemic	Vegetation types	Elevation zones	Life form	Chorotype
Fibigia macrocarpa (Boiss.) Boiss.	-	4, 6	ms	He	IT
Fibigia suffruticosa (Vent.) Sweet	-	4, 6	ms	He	IT
Fibigia umbellata (Boiss.) Boiss.	-	6	a	He	IT
Graellsia saxifragifolia (DC.) Boiss.	-	3	a	He	IT
Isatis cappadocica Desv.	-	6	s	He	IT
Isatis kotschyana Boiss. & Hohen. ex Boiss.	-	4, 6	ms	He	IT
Lepidium latifolium L.	-	1	ms	Ge	IT, M, ES
Matthiola alyssifolia Bornm.	-	4, 6	ms	He	IT
Matthiola ovatifolia Boiss.	Ir	4, 6	ms	He	IT, M
Peltaria angustifolia DC.	-	4	m	Th	IT
Pseudocamelina aphragmodes (Boiss.) N. Busch	Za	6	a	He	IT
Pseudocamelina campylocarpa (Boiss.) N. Busch	Za	6	s	He	IT
Pseudocamelina glaucophylla N. Busch	Ir	4, 6	ms	He	IT
Campanulaceae					
Asyneuma cichoriiforme (Boiss.) Bornm.	-	4, 6	ms	He	IT, M
Caprifoliaceae					
Cephalaria juncea Boiss.	Ir	4, 6	ms	He	IT
Cephalaria microcephala Boiss.	-	6	s	He	IT
Cephalaria syriaca (L.) Schrad. ex Roem. & Schult.	-	4, 6	ms	Th	IT, M, ES
Pterocephalus canus Coult. ex DC.	-	4, 6	ms	He	IT
Pterocephalus ghahremanii Jamzad	Za	6	s	He	IT
Valeriana sisymbriifolia Kabath	-	5, 6	s	He	IT
Caryophyllaceae					
Acanthophyllum crassifolium Boiss.	-	4, 6	ms	Ch	IT
Arenaria persica Boiss.	Za	6	a	Ch	IT
Arenaria serpyllifolia L.	-	4, 6	ms	Th	Plur
Cerastium dichotomum L.	-	4, 6	ms	Th	Plur
Dianthus libanotis Labill.	-	4, 6	ms	Ch	IT, ES
Dianthus macranthus Boiss.	Ir	6	s	He	IT
Gypsophila persica Barkoudak	Ir	4, 6	ms	He	IT
Gypsophila virgata Boiss.	-	4, 6	ms	Ch	IT
Mesostemma kotschyanum (Fenzl ex Boiss.) Vved.	-	5	s	He	IT
Minuartia lineata Bornm.	-	6	sa	He	IT
Silene aucheriana Boiss.	-	6	sa	He	IT, ES
Silene chlorifolia Sm.	-	6	sa	He	IT, ES
Silene morganae Freyn	-	4, 6	ms	He	IT, M, ES
Silene meyeri Fenzl ex Boiss. & Buhse	-	3	sa	Ch	IT, ES
Vaccaria grandiflora Jaub. & Spach	-	1	lm	Th	Plur
Convolvulaceae					
Convolvulus arvensis L.	-	1	lm	He	Cosm
Convolvulus urosepalus Pau.	Za	6	s	Ch	IT
Cuscuta campestris Yunck.	-	1	lm	Th	Plur
Crassulaceae					
Rosularia elymaitica (Boiss. & Hausskn. ex Boiss.) A. Berger	Ir	3	s	He	IT, ES
Cupressaceae					
Juniperus excelsa M.Bieb.	-	3	s	Ph	IT, ES
Cyperaceae					
Carex microglochin Wahlenb.	-	2	a	Ge	Plur
Eleocharis uniglumis (Link) Schult.	-	4	m	He	Cosm
Equisetaceae					
Equisetum arvense L.	-	2	lm	He	Plur
Euphorbiaceae					
Euphorbia decipiens Boiss. & Buhse	Ir	6	s	He	IT
Euphorbia heteradena Jaub. & Spach	-	4, 5, 6	ms	He	IT, ES
Fabaceae					
Astragalus alyssoides Lam.	-	6	sa	He	IT
Astragalus andalanicus Boiss. & Hausskn.	-	6	sa	Ch	IT
Astragalus apricus Bunge	-	6	sa	He	IT
Astragalus brachycalyx Phil.	-	6	s	Ch	IT
Astragalus brachyodontus Boiss.	Ir	4, 6	ms	He	IT
Astragalus callistachys Buhse	Ir	4	m	Ch	IT
Astragalus cephalanthus DC.	Ir	4, 6	ms	Ch	IT
Astragalus chrysotrichus Boiss.	Za	4, 6	ms	He	IT
Astragalus compactus Reiche	-	6	s	Ch	IT, ES
Astragalus curvirostris Boiss.	-	4, 6	ms	He	IT, ES, SS

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Astragalus cyclophyllon Beck	Ir	4, 6	ms	He	IT
Astragalus eriosphaerus Boiss. & Hausskn.	Ir	4, 6	ms	Ch	IT
Astragalus fragiferus Bunge	Ir	6	a	Ch	IT
Astragalus holopsilus Bunge	Za	4, 6	ms	He	IT
Astragalus megalotropis Bunge	-	4, 6	ms	He	IT, ES
Astragalus microphysa Boiss.	Ir	6	a	Ch	IT
Astragalus murinus Boiss.	Za	6	a	Ch	IT
Astragalus ovinus Boiss.	-	5, 6	sa	He	IT
Astragalus patrius Maassoumi	Ir	6	a	He	IT, ES
Astragalus ptychophyllus Boiss.	Za	4, 6	ms	Ch	IT
Astragalus raswendicus Hausskn. & Bornm.	Za	6	s	Ch	IT
Astragalus rhodosemius Boiss. & Hausskn.	Ir	6	sa	Ch	IT
Astragalus susianus Boiss.	Za	6	Sa	Ch	IT
Cicer oxyodon Boiss. & Hohen.	-	4, 5, 6	ms	He	IT
Cicer spiroceras Jaub. & Spach	Ir	4, 5, 6	ms	He	IT
Coronilla varia L.	-	4	lm	He	IT, M, ES
Lotus corniculatus L.	-	4, 5, 6	ms	He	IT, M, ES
Onobrychis cornuta (L.) Desv.	-	6	sa	Ch	IT, Es
Ononis spinosa L.	-	2	lm	Ch	IT, M, ES
Oxytropis chrysocarpa Boiss.	-	6	a	He	IT
Trigonella aphanoneura Rech.f.	Za	5	s	He	IT
Vicia variabilis Freyn & Sint. ex Freyn	-	4, 5, 6	ls	He	IT
Gentianaceae					
Centaurium erythraea Rafn	-	6	s	He	IT, M, ES
Gentiana olivieri Griseb.	-	4, 5, 6	ms	He	IT, ES
Geraniaceae					
Erodium cicutarium (L.) L'Hér.	-	4	m	Th	IT, M, ES
Geranium persicum Schönb.-Tem.	-	4, 5, 6	ms	Ge	IT
Geranium tuberosum L.	-	4, 5, 6	ms	Ge	IT, M, ES
Hypericaceae					
Hypericum scabrum L.	-	4, 5, 6	ms	He	IT, ES
Iridaceae					
Iris iberica Steven.	-	4, 6	ms	Ge	IT
Iris hymenospatha B.Mathew & Wendelbo	Ir	4	m	Ge	IT
Ixioliriaceae					
Ixiolirion tataricum (Pall.) Schult. & Schult.f.	-	4	m	Ge	Plur
Juncaceae					
Juncus articulatus L.	-	2	m	Ge	Plur
Juncus bufonius L.	-	2	ms	Th	Cosm
Juncus turkestanicus V.I.Krecz. & Gontsch.	-	2	ls	Th	IT, ES
Juncus inflexus L.	-	2	ls	He	Cosm
Juncaginaceae					
Triglochin palustris L.	-	2	ls	Ge	Plur
Lamiaceae					
Dracocephalum kotschyi Boiss.	Ir	6	s	Ch	IT
Eremostachys macrophylla Montbret & Aucher ex Benth.	-	4, 5, 6	ms	He	IT, ES
Lamium amplexicaule L.	-	1	lm	Th	IT, M, ES
Mentha longifolia (L.) L.	-	2	ms	He	Plur
Nepeta laxiflora Benth.	Za	5, 6	s	He	IT
Nepeta lasiocephala Benth.	Ir	6	a	He	IT
Nepeta persica Boiss.	-	4, 5, 6	ms	Ch	IT
Nepeta sessilifolia Bunge	Ir	3	a	He	IT
Nepeta sintenisii Bornm.	-	4, 5, 6	ms	He	IT
Phlomis anisodonta Boiss.	Ir	6	sa	He	IT
Phlomis olivieri Benth.	-	4	lm	Ch	IT
Salvia aristata Aucher ex Benth.	Ir	4	m	He	IT
Salvia atropatana Bunge	-	4, 6	ms	He	IT
Salvia hydrangea DC. ex Benth.	-	4, 5, 6	ms	He	IT, M
Salvia sclarea L.	-	4, 6	ms	He	IT, M, ES
Scutellaria multicaulis Boiss.	Ir	6	sa	He	IT
Scutellaria pinnatifida A.Ham.	-	5, 6	s	He	IT
Stachys acerosa Boiss.	Ir	5, 6	sa	Ch	IT
Stachys benthamiana Boiss.	Ir	4, 6	ms	He	IT
Stachys inflata Benth.	-	4, 6	ms	He	IT, ES, SS
Stachys lavandulifolia Vahl	-	4, 6	ms	He	IT, ES

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Stachys pilifera Benth.	Za	6	a	He	IT
Teucrium orientale L.	-	4, 5, 6	ls	He	IT, ES
Thymus carmanicus Jalas	-	6	a	Ch	IT
Thymus daenensis Celak.	Ir	6	s	He	IT
Thymus kotschyanus Boiss. & Hohen.	-	4, 6	ms	Ch	IT
Ziziphora clinopodioides Lam.	-	4, 6	ms	Ch	IT, ES
Liliaceae					
Fritillaria imperialis L.	-	5, 6	s	Ge	IT
Fritillaria persica L.	-	5, 6	s	Ge	IT
Fritillaria reuteri Boiss.	Ir	2	s	Ge	IT
Gagea gageoides (Zucc.) Vved.	-	2	ms	Ge	IT, ES
Ornithogalum orthophyllum Ten.	-	4	ms	Ge	Plur
Tulipa biflora Pall.	-	4, 5, 6	ms	Ge	IT, ES
Tulipa stylosa Fisch.	-	4, 5, 6	ms	Ge	IT
Linaceae					
Linum album Kotschy ex Boiss.	Ir	4	m	He	IT
Onagraceae					
Epilobium hirsutum L.	-	2	lm	He	Plur
Orchidaceae					
Dactylorhiza umbrosa (Kar. & Kir.) Nevski	-	2	ms	Ge	IT, ES
Papaveraceae					
Corydalis rupestris Kotschy	-	3	s	Ge	IT, ES
Glaucium corniculatum (L.) Curtis	-	4	m	Th	Cosm
Papaver armeniacum (L.) DC	-	6	sa	He	IT
Papaver cylindricum Cullen	-	4	m	Th	IT, M, ES
Papaver decaisnei Hochst. & Steud. ex Elkan	-	4	m	Th	IT, SS
Roemeria refracta DC.	-	1	lm	Th	IT, ES, SS
Plantaginaceae					
Linaria lineolata Boiss.	-	5, 6	s	He	IT, ES
Linaria pyramidalis F.Dietr.	-	5, 6	s	He	IT, ES
Plantago lanceolata L.	-	4	m	He	Plur
Veronica farinosa Hausskn.	Za	5, 6	s	He	IT
Veronica orientalis Mill.	-	4, 5, 6	ms	He	IT, M, ES
Plumbaginaceae					
Acantholimon aspadanum Bunge	Za	6	sa	Ch	IT
Acantholimon hohenackeri (Jaub. & Spach) Boiss.	-	6	s	Ch	IT
Acantholimon senganense Bunge	-	6	sa	Ch	IT
Poaceae					
Arrhenatherum kotschyi Boiss.	-	4	m	Ge	IT
Boissiera squarrosa (Sol.) Nevski	-	4	m	Th	Plur
Bromus danthoniae Trin.	-	4	lm	Th	IT, ES, SS
Bromus tectorum L.	-	4	lm	Th	Cosm
Bromus tomentellus Boiss.	-	6	s	He	IT, M, ES
Cynodon dactylon (L.) Pers.	-	4	m	Ge	Cosm
Dactylis glomerata L.	-	4, 6	ls	He	Cosm
Eremopoa persica (Trin.) Roshev.	-	4, 5, 6	ms	Th	Plur
Heteranthelium piliferum (Sol.) Hochst. ex Jaub. & Spach	-	4	lm	Th	IT, M, ES
Hordeum violaceum Boiss. & Hohen.	-	2	s	He	IT, M, ES
Melica jacquemontii Decne.	-	6	s	Ge	Plur
Melica persica Kunth.	-	6	s	Ge	IT
Poa bulbosa L.	-	4, 6	ls	Ge	Plur
Setaria viridis (L.) P.Beauv.	-	4	lm	Th	Plur
Sorghum halepense (L.) Pers.	-	1	lm	Ge	Cosm
Stipa lagascae Roem. & Schult.	-	4	lm	He	IT, SS
Taeniatherum crinitum (Schreb.) Nevski	-	4	lm	Th	Plur
Zingeria trichopoda (Boiss.) P.A.Smirn.	-	4	m	Th	IT, M
Polygonaceae					
Atraphaxis spinosa L.	-	4	m	Ch	Plur
Polygonum arenastrum Boreau	-	4, 5, 6	ls	Th	Plur
Rheum ribes L.	-	6	s	He	IT, M, ES
Primulaceae					
Dionysia bazoftica Jamzad	Za	3	a	Ch	IT
Ranunculaceae					
Adonis aestivalis L.	-	1	lm	Th	IT, M, ES
Anemone biflora DC.	-	4, 5, 6	ms	Ge	IT, ES

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Ceratocephala falcata (L.) Pers.	-	4	lm	Th	IT, M, ES
Consolida barbata (Bunge) Schrödinger	-	4	lm	Th	IT, ES
Ficaria kochii (Ledeb.) Iranshahr & Rech.f.	-	4, 5, 6	ms	Ge	IT
Ranunculus arvensis L.	-	1	m	Th	IT, M, ES
Thalictrum isopyroides C.A. Mey	-	4, 6	ls	He	IT, ES
Resedaceae					
Reseda lutea L.	-	4	m	He	Plur
Rhamnaceae					
Rhamnus cornifolia Boiss. & Hohen.	-	6	s	Ch	IT
Rosaceae					
Amygdalus haussknechtii (C.K.Schneid.) Bornm.	Ir	4, 6	ms	Ph	IT
Cerasus brachypetala Boiss.	-	6	s	Ph	IT
Cerasus mahaleb (L.) Mill.	-	6	s	Ph	Plur
Cerasus microcarpa (C.A.Mey.) K.Koch	-	6	s	Ph	IT
Cerasus pseudoprostrata Pojark.	-	6	s	Ch	IT
Cotoneaster nummularius Fisch. & C.A.Mey.	-	4	m	Ph	Plur
Cotoneaster luristanicus G.Klotz	-	4	m	Ph	IT
Potentilla recta L.	-	4	m	He	Plur
Rosa canina L.	-	4	lm	Ph	IT, M, ES
Rosa orientalis A.Dupont ex Ser.	-	4, 6	ms	Ph	IT
Sanguisorba minor Scop.	-	4	m	He	Plur
Rubiaceae					
Asperula rechingeri Ehrend. & Schönb.-Tem.	Ir	6	a	He	IT
Callipeltis cucullaris (L.) DC.	-	4, 5, 6	ms	Th	IT, ES, SS
Cruciata laevipes Opiz	-	4, 5, 6	ls	He	Plur
Cruciata taurica (Pall. ex Willd.) Ehrend.	-	4	ms	He	IT, M, ES
Galium megalanthum Boiss.	-	6	s	He	IT
Galium pseudokurdicum (Ehrend.) Schönb.-Tem.	-	6	a	Ch	IT
Galium subvelutinum (DC.) K.Koch	-	6	s	He	IT
Galium verum L.	-	4	m	He	Cosm
Rubia rigidifolia Pojark.	Ir	4, 5, 6	ms	Ch	IT
Scrophulariaceae					
Scrophularia frigida Boiss.	Ir	6	a	He	IT
Scrophularia nervosa Benth.	Ir	4, 6	ms	He	IT
Scrophularia striata Boiss.	-	4	lm	He	IT
Verbascum speciosum Schrad.	-	4	lm	He	IT, ES
Solanaceae					
Hyoscyamus kurdicus Bornm.	-	6	s	He	IT
Thymeleaceae					
Daphne mucronata Royle	-	4, 6	ms	Ph	IT, SS
Valerianaceae					
Valerianella dactylophylla Boiss. & Hohen.	-	4	lm	Th	IT, M, ES

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